3.4 Low-Frequency Noise

3.4.1 Existing Conditions

3.4.1.1 Background Information on Low-Frequency Noise

It has long been recognized that gas turbine power plants can cause a variety of noise impacts to the surrounding community (Newman and McEwan 1979). The types of power plant noise that can cause community annoyance include the following:

Broad-Band Noise

This is the overall sound level under conditions when no specific frequency ranges are readily discernible. Broad-band noise is typically measured as A-weighted decibels (dBA). The A-weighting decibel scale accounts for noise in all frequency bands normally perceptible to humans, including low-frequency noise. Broad-band noise is regulated in Whatcom County. SE2 performed predictive modeling as part of the Second Revised ASC to demonstrate compliance with the county's noise ordinance.

Low-Frequency Noise

This is characterized by noise levels at frequencies less than about 100 hertz (Hz). For this SEIS, low-frequency noise is described as noise levels in the 16 Hz, 32 Hz, and 64 Hz octave bands. Noise at those frequencies can be annoying to some people even at relatively low levels that might not be discernible to other people standing nearby (van den Berg 1998). Low-frequency noise can propagate through closed windows and lightweight walls typical of most homes, so in many cases the indoor and outdoor levels at homes near sources of low-frequency noise can be nearly identical. For that reason, annoyance from low-frequency noise usually occurs when the receiver is indoors where the background noise levels are low compared to the intruding low-frequency noise. If the low-frequency noise level is sufficiently high, it can cause discernable vibration and rattling of windows or other lightweight structures.

Tonal Noise

Noise from gas turbines can sometimes cause a "whine" with a distinct tonal quality. These tones can be readily discernible (and therefore be potentially annoying) even when the overall broad-band noise level is low.

Periodic Beats

In some cases where two sources of low-frequency noise operate near each other (e.g., two adjacent turbines operating at the S2GF), sound waves propagating away from the sources can interact to cause repetitive low-frequency "beats." These periodic beats can be readily discernible (and be potentially annoying) even when the overall noise level is low.

3.4.1.2 Regulatory Framework

Current Whatcom County and Washington State noise ordinances regulate only broad-band noise (expressed as dBA). Therefore, there are no quantitative regulatory limits on low-frequency noise, tonal noise, or repetitive beats applicable to the S2GF. However, other regulatory agencies in the region have quantitative limits on these types of noise, which could be used as guidance to assess the impacts of low-frequency noise and tonal noise emitted by the S2GF.

The King County, Washington noise ordinance specifies adjustment factors to reduce the allowable broad-band noise limits (expressed as dBA) if the noise source produces either tonal noise or repetitive, periodic noise. The King County ordinance provides quantitative definitions for the terms "pure tone component" and "periodic sound." If the noise source emits either of those types of annoying noise, then the allowable dBA limits at the receiving property are reduced by 5 dBA.

The state of Oregon noise regulation (OAR 340-035-0035) specifies allowable limits on octave-band noise levels at the receiving property. The allowable limits for the 32 Hz and 64 Hz octave bands are 65 dB and 62 dB, respectively. Oregon also imposes a 5-dBA adjustment factor to allowable broad-band noise limits for cases where the intruding noise is either tonal or repetitive.

3.4.1.3 Existing Low-Frequency Noise Levels

SE2 has not provided EFSEC with baseline measurements of low-frequency noise levels at receivers near the project site. Long-term measurements of A-weighted noise levels were taken at numerous residential receivers as part of SE2's noise impact assessment. However, those previous A-weighted noise level measurements cannot be used to assess existing low-frequency noise levels near the project site.

There are two existing industrial facilities operating near the project site that could contribute to baseline low-frequency noise levels: the existing SE1 gas turbine power plant and a manufacturing plant (IKO Roofing) operating south of the proposed S2GF plant location. Both of those facilities are smaller than the proposed S2GF turbines and are farther from the residentially-zoned parcels that could be affected by low-frequency noise generated by the S2GF.

3.4.2 Environmental Impacts

3.4.2.1 Project-Related Sources of Low-Frequency Noise

SE2 has not initiated final design of the plant, so accurate estimates of the low-frequency sound power-level noise emissions from each major equipment item are not available. However, based on preliminary data provided by SE2 for its predictive modeling of broad-band noise impacts, the following equipment items are presumed to be the major sources of potential low-frequency noise:

- Exhaust stacks
- Heat recovery steam generator (HRSG) wall noise
- Air inlet filter houses

Most of the other equipment would be either indoors or shielded by the tall buildings at the site.

3.4.2.2 Estimated Future Low-Frequency Noise Levels at Residential Receivers

As part of the Second Revised ASC, SE2 conducted predictive modeling of the A-weighted broad-band noise levels at four residential receivers near the S2GF. The noise modeling was done using the Environmental Noise Model (ENM), which accounts for barrier attenuation provided by the tall structures at the project site and for meteorological factors, including wind and temperature inversions. The modeling showed that the predicted A-weighted noise levels caused solely by the S2GF sources (not including background) met both the daytime and nighttime noise limits set by Whatcom County and Washington State noise regulations. If background noise levels were added to the modeled noise impacts caused solely by the S2GF sources, it is possible that the total noise levels would be higher than the Washington State limits for nighttime noise.

However, SE2 did not provide the results of either baseline noise measurements or predictive modeling of the future sound levels at the 32 Hz and 64 Hz octave bands. Therefore, at this time it is not possible to determine whether or not the low-frequency noise levels produced by the S2GF would result in an impact or if they would exceed the limits of the state of Oregon's noise ordinance, which is recommended as a project-specific noise limit (see Section 3.4.3.3).

3.4.3 Mitigation Measures

The S2GF includes several design features to reduce low-frequency noise. For example, SE2 states that the use of the HRSG downstream of the combustion turbine serves as a silencer for low-frequency noise that might otherwise be associated with a turbine used in

a single-cycle configuration. In addition, as part of its Second Revised ASC, SE2 proposed the following mitigation for low-frequency noise and tonal noise:

> To address additional concerns about noise, SE2 will monitor sound levels before construction and after operation of the S2GF. In addition to monitoring sound metrics related to demonstrating compliance with county and city noise regulations, SE2 will evaluate low-frequency sound and tones. The monitoring shall include a minimum of 12 locations up to a distance of 3.5 miles from the plant. SE2 will select measurement locations in concert with city of Sumas or Whatcom County staff, focusing on residential locations.
>
> Post operational noise measurements shall begin within 2 months of the commencement of operation. If monitoring indicates that the plant is not in compliance with city or county noise regulations or that the S2GF generates low-frequency sounds or tones that city and county noise regulation staff jointly agree are reasonably objectionable, SE2 engineers will investigate the source of the noise and identify one or more means of mitigating the noise. At the end of the S2GF's first operational year, SE2 will submit for the Council's approval a report providing the pre- and post-operation monitoring results and any mitigation plan found to be necessary.
>
> Once post-operational monitoring indicates the plant is in compliance with city and county noise regulations and that there is no reasonably objectionable low-frequency noise or tones, the noise monitoring program will be deemed complete.

SE2 and its noise engineers later clarified the proposed mitigation with two additional proposed conditions:

- The results of the post-startup noise monitoring would be submitted to EFSEC within 60 days after startup (rather than 1 year after startup), and SE2 would commit to implementing any required corrective measures as soon as practicable.
- SE2 could submit engineering design packages and predictive noise modeling for review by EFSEC before plant startup would be allowed. Review of SE2's design and noise modeling would provide assurance that the design of the plant was adequate to comply with relevant noise limits.

Although SE2 has not proposed specific mitigation measures, it has identified potential mitigation measures to address low-frequency noise at the generating facility. These measures are described in the following sections.

3.4.3.1 Potential Noise Reduction Design Measures

Some of the feasible mitigation measures could be designed into the project and installed as a part of construction. However, some of them would be difficult to incorporate after the facility has been constructed. These include:

- Installation of HRSG stack silencers
- Specification of low-frequency noise limits for equipment
- Use of low-noise fans for cooling towers
- Installation of low-noise transformers
- Avoidance of use of centrifugal fans for building ventilation

3.4.3.2 Potential Retrofit Noise Mitigation Measures

Some of the potential mitigation measures identified by SE2 could be applied as retrofits to original equipment after the facility has commenced operation. These include the following:

- Thicker HRSG walls
- Heavier building walls
- Reactive silencers
- Noise barriers or enclosures at outdoor equipment
- Absorptive panels at the bottom of the stacks

SE2 also listed "active noise control" as a potential mitigation. Active noise control uses microphones to detect sound waves emitted by the source and speakers to emit sound waves that match the waves emitted by the source, thereby canceling the sound waves emitted by the source. This technology can be highly effective but it is not applicable to all of the sources at the S2GF. Active noise control is currently commercially available only for simple industrial noise sources such as ventilation ducts handling ambient temperature gas streams. Aircraft engine manufacturers and research institutes are developing active noise control for gas turbines and high-temperature industrial stacks, but these systems are not yet commercially available.

Although the measures listed above were proposed, no analysis of their effectiveness was offered by SE2.

3.4.3.3 Recommended Mitigation Measures

As described previously, there has been considerable research into low-frequency noise. This noise can annoy some people more than others and the occurrence of the annoyance can vary during the course of the day depending on background conditions (van den Berg 1998). Therefore, SE2's proposal to establish an environmental impact criterion for low-frequency noise after the plant has already been built and "that city and county noise regulation staff jointly agree are reasonably objectionable," might not result in levels of low-frequency noise that are acceptable to residents near the S2GF. To provide assurance that the plant is designed to provide adequate noise control, the following special conditions should be included in the SCA.

Establish Quantitative Low-frequency Noise Limits and Discrete Tonal Noise Limits Prior to Construction

Prior to construction of the S2GF, SE2 could research, for council approval, literature and numerical noise limits from other jurisdictions to develop a reasonable criterion for allowable low-frequency noise and pure tones at the nearest residential receivers. For this project "residential receivers" should include the following:

- Any existing dwelling within 3.5 miles of the plant (in the U.S. or Canada), regardless of the land use zoning of the parcel on which the dwelling is located (a "dwelling" is defined as a building where people reside and sleep)

- Any parcel zoned "Residential" within 3.5 miles of the plant

Examples of published information addressing low-level noise limits include the following:

- The American National Standards Institute (ANSI) Bulletin S12.9-1996/Part 4 states "Generally, annoyance is minimal when octave-band sound pressure levels are less than 65 dB at 16 Hz, 32 Hz and 64 Hz midband frequencies."

- The Oregon State noise regulation (OAR 340-035-0035) specifies allowable octave-band nighttime exterior noise levels at residential areas of 65 dB and 62 dB at 32 Hz and 64 Hz, respectively.

- The American Society of Mechanical Engineers document entitled "Low Frequency Gas Turbine Noise" (Newman and McEwan 1979) states that "The criterion now used by the British Gas Corporation when specifying noise control for gas turbines is 60 dB in the 32 Hz octave band at the nearest dwelling."

The SCA for the project should include a special condition specifying the following criteria for low-frequency outdoor noise levels at residential receivers near the proposed S2GF:

- 32 Hz octave band: 65 dB
- 64 Hz octave band: 62 dB

There appear to be few reliable data from power plant manufacturers regarding noise emissions at the 16 Hz octave band, so it would be unreasonable to require SE2 to do predictive modeling of future noise levels at that frequency. Similarly, the preliminary literature review done for this SEIS indicated no relevant outdoor ambient noise limits for the 16 Hz octave band. Therefore, no ambient noise limits for the 16 Hz octave band are recommended.

The SCA should specify allowable outdoor noise limits for discrete tones by incorporating the limits in Section 340-35-035(1)(f)(B), "Audible Discrete Tones," from the Oregon noise regulation. That rule prohibits an industrial facility from causing

discrete tones at a residential receiver. "Discrete tones" are defined in the rule based on comparison of measured one-third octave band noise levels. The Oregon noise limit is as follows:

> One-third Octave Band. No person owning or controlling an industrial or commercial noise source shall cause or permit the operation of that noise source if such operation generates a median one-third octave band sound pressure level which…in a one-third octave band at a preferred frequency, exceeds the arithmetic average of the median sound pressure levels of the two adjacent one-third octave bands by:
>
> (i) 5 dB for such one-third octave band with a center frequency from 500 Hertz to 10,000 Hertz, inclusive. Provided: Such one-third octave band sound pressure level exceeds the sound pressure level of each adjacent one-third octave band; or
>
> (ii) 8 dB for such one-third octave band with a center frequency from 160 Hertz to 400 Hertz, inclusive. Provided: Such one-third octave band sound pressure level exceeds the sound pressure level of each adjacent one-third octave band; or
>
> (iii) 15 dB for such one-third octave band with a center frequency from 25 Hertz to 125 Hertz, inclusive. Provided: Such one-third octave band sound pressure level exceeds the sound pressure level of each adjacent one-third octave band.

The recommended project-specific noise limits are the same as those specified by the Oregon noise regulation. There are currently several large power plants operating in Oregon that have successfully demonstrated compliance with this noise standard, so it would be reasonable to establish these limits as special conditions for the S2GF. The SCA should include a provision allowing SE2 to propose alternate limits prior to startup of the plant, subject to review and approval by EFSEC.

Conduct Predictive Noise Modeling and Submit Engineering Package for Design Review Prior to S2GF Startup

The SCA should include a special condition requiring SE2 to submit design packages for review and approval by EFSEC before startup of the facility is allowed. EFSEC's design review would focus on noise control measures and SE2's specifications for vendor guarantees of noise emissions. The design package should be submitted at the 50% complete level.

As noted above, as part of the ASC process SE2 conducted a modeling study to demonstrate that broad-band noise from the plant complied with the county's existing noise limits. A similar modeling study should be required as part of the 50% complete design package submittal. The input to the noise model should reflect the vendor guarantees specified in the 50% complete design package. The noise model should demonstrate compliance with the low-frequency ambient noise limits.

3.4.4 Significant Unavoidable Adverse Impacts

SE2 has committed to post-startup noise monitoring and immediate installation of any noise mitigation required to comply with project-specific noise criteria for low-frequency noise and pure tones. Therefore, there would be no significant unavoidable adverse noise impacts.